



Habitability and Human Factors Contributions to Human Space Flight

Portfolio

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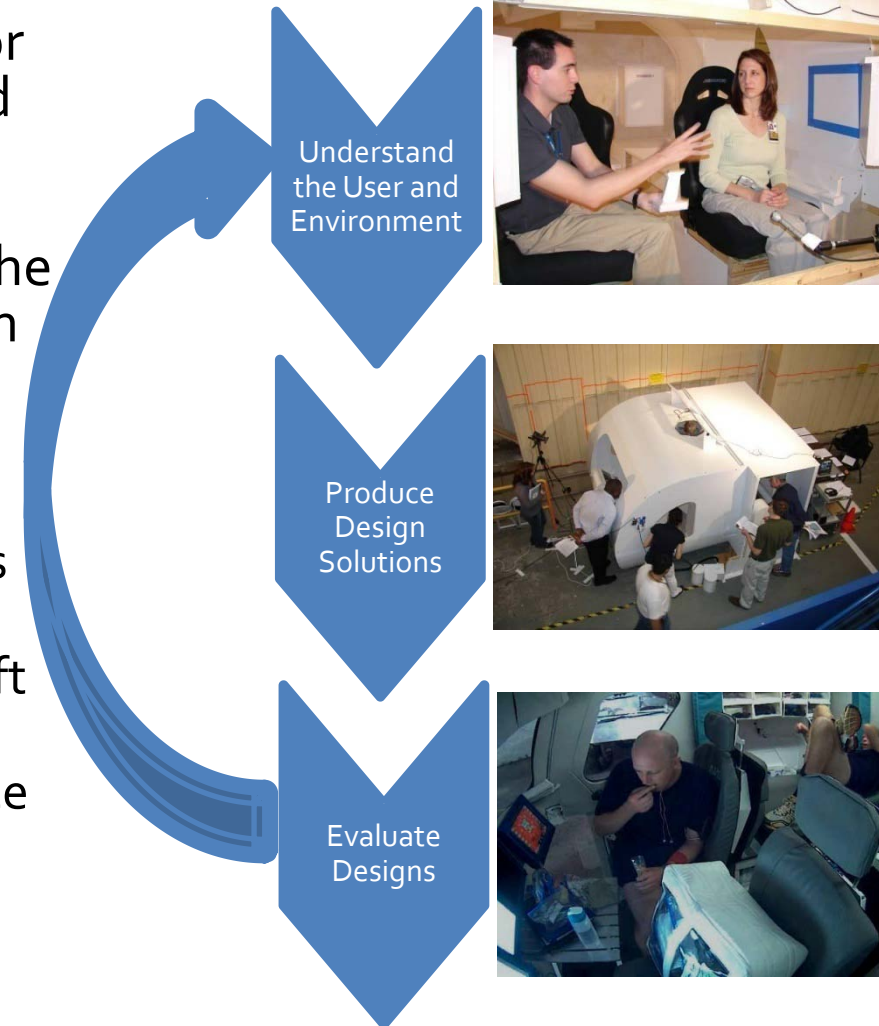
Introduction to Human Factors



The field of Human Factors applies knowledge of human characteristics for the design of safer, more effective, and more efficient systems.

In specific application to space systems, the Habitability and Human Factors Branch at NASA

- Creates conceptual designs for habitats and crew systems
- Establishes standards and requirements
- Verifies human-machine interfaces and the operational habitability of spacecraft and habitats
- Oversees and conducts research in space human factors to improve human performance and productivity

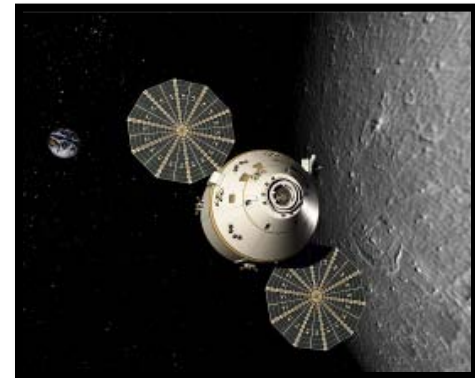


Support to Program Work and Research



The Habitability and Human Factors Branch supports human space flight in two main areas:

- Applied support to major space programs
 - Shuttle Space Transportation System
 - International Space Station
 - Constellation Program
 - Orion, EVA, Altair, and Lunar Habitats
 - Commercial Programs
- Space research
 - Space Human Factors Engineering Directed Research funded by the Human Research Program
 - Research projects with external businesses and universities

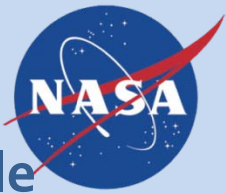




Human-System Integration

Human-System Integration (HSI)

Ensuring human health and performance throughout the life cycle



The Habitability and Human Factors Branch is leading the effort to establish a HSI program at NASA.

HSI as a key component of Systems Engineering reduces Program costs, improves system performance, and increases human safety.

HSI Execution:

- Applying Agency standards to Programs
- Developing verifiable Program requirements
- Providing requirements interpretations
- Working hand-in-hand with Prime contractors
- Executing Human-Centered Design Principles

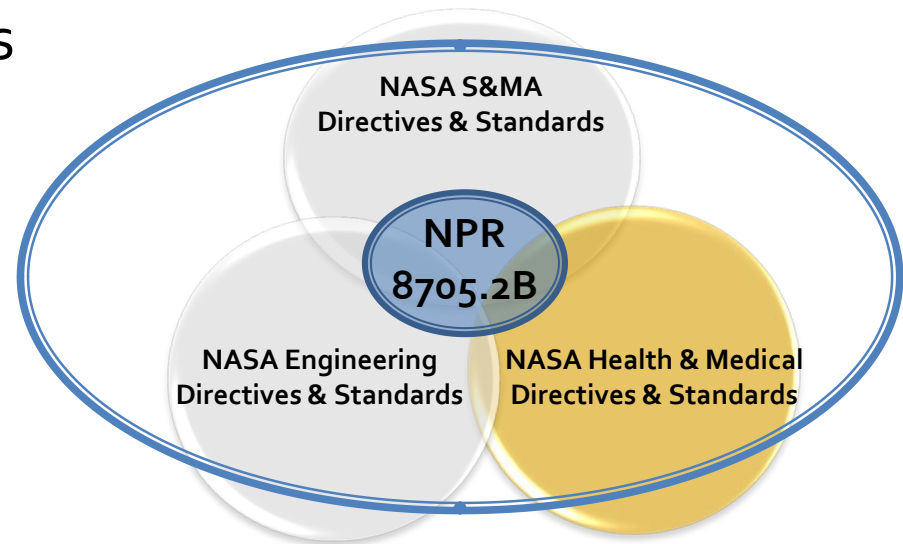
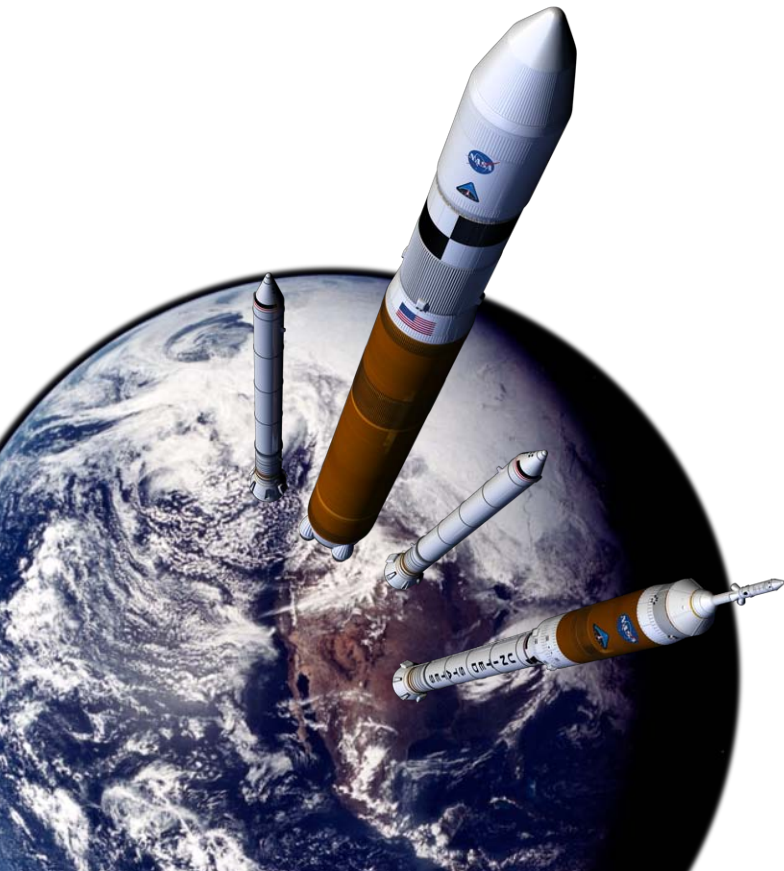


Human-System Integration (HSI)

Human-Rating Implementation



Habitability and Human Factors
Branch provides expertise in
human-rating compliance.



NPR 8705.2B provides the roadmap for Program-specific requirements to be derived for each NASA Program ensuring that spacecraft and mission systems design is centered on the needs, capabilities, and limitations of the human.

Key aspects of human-rating implementation for Constellation include:

**workload *iterative human-in-the-loop testing *usability
*handling qualities *human-system integration*

Human-System Integration (HSI)

Standards and Requirements Development



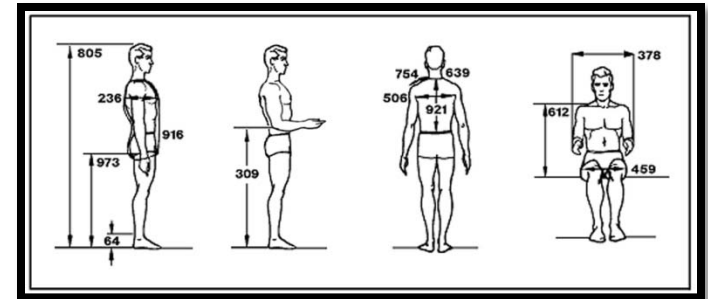
Ensuring safe and efficient crewed space flight through the development of human-system standards and requirements.

Processes:

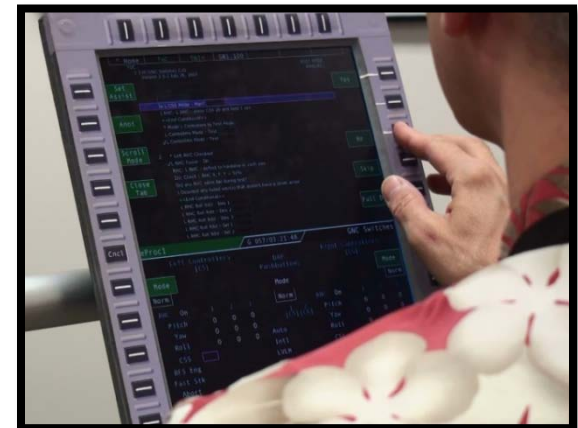
- Integrate support for all human-system requirements and verifications
- Establish process for the development of human-system requirements from NASA Standards
- Institute an iterative life cycle for continual improvements based on lessons learned, risk mitigation, trade and research studies

Products:

- Space Flight Human-Systems Standard (NASA-STD-3001)
- Human Integration Design Handbook (HIDH)
- Commercial Human Systems Integrations Requirements (CHSIR)
- Commercial Human Systems Integrations Processes (CHSIP)
- Human Systems Integrations Requirements (HSIR)
- ISS Flight Crew Integration Standard (SSP 50005)
- Orion Program Display Format Standards (CxP 72242)



Research on human anthropometry, strength, and range of motion has led to the development of anthropometric requirements for space suit and vehicle design



Human Factors researchers have created the first ever quantitative Usability metric at NASA



Orion Crew Exploration Vehicle

Orion Task Analysis



By requiring task analysis in Human Systems Integration Requirements (HSIR) for the first time at NASA, task analysis was used to mature the concept of operations and ensure that design is task driven.



Ascent



On-Orbit



Post-Landing

A multi-disciplinary team used a consistent task analysis approach that defined the crew tasks for all mission phases. This highly successful process created an accepted task list to be used for HSIR verification, and identified developmental forward work items

Orion Human-In-The Loop Evaluations

Collaborative evaluation for optimized design



Early and iterative human-in-the-loop (HITL) evaluations:

- Reveal design and integration problems, and opportunities for cost efficient improvements
- Extend the design process beyond 2D modeling to include interactive 3D human task performance
- Spearhead verification planning



Vehicle Ingress/Egress

Focused HITL Evaluations leading to Design Improvements

- Display & Controls
- Seat Design, Ingress and Egress
- Crew Vehicle Egress & Survival Operations
- Stowage
- Habitability & Environmental Systems
- Net Habitable Volume
- Docking Camera Design and Operations
- Hatches & Hatch Height
- Windows



Displays and Controls



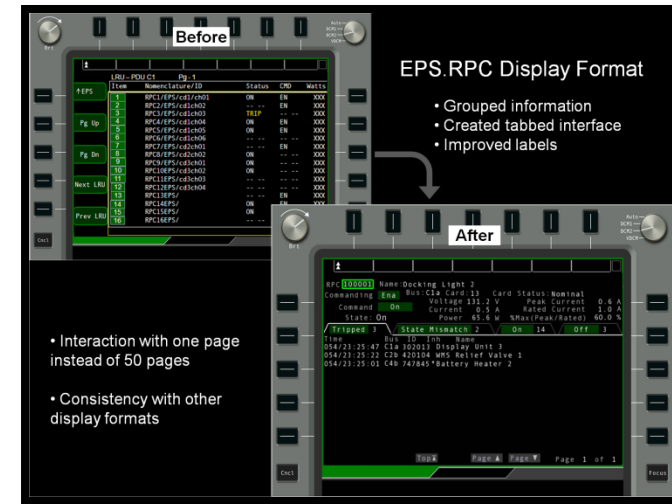
Seat Design

Orion Displays and Controls

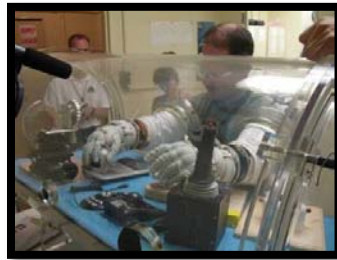
Prototyping & Evaluation



Human engineering improves the design of displays and controls for Orion by establishing display format standards and applying a rigorous human factors process.



Display format before and after human factors input and evaluation



Evaluations of controls in reduced gravity and under pressurization



Edge key design



Generation of the cursor control device, from a clay model to the final product, including ergonomic and functional testing



Iterative design of abort control



Human factors input resulted in increased in-line and cross-cockpit viewability, improved reach and access to controls, better labeling and use of LEDs, and improved organization and placement of controls.

Orion Net Habitable Volume (NHV)



Habitability evaluation of the Orion Net Habitable Volume improves mission safety and success, and ensures that the crew has adequate volume to perform critical mission tasks.



Radiation Shelter



Medical Operations



Habitability Design Center developed a volumetric representation of Orion. An accurate mockup is critical to the successful evaluation of net habitable volume.



Suit Donning



Cabin Reconfiguration

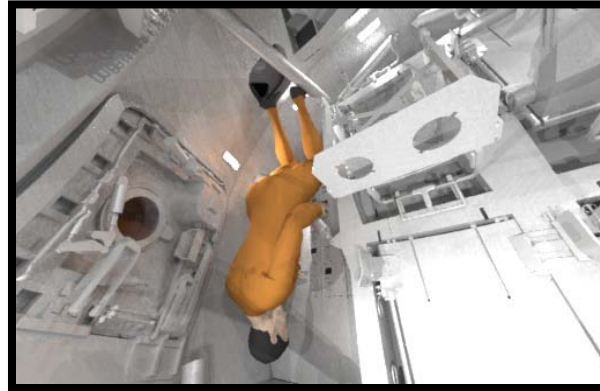
Evaluation of volume driving tasks, such as suit donning and doffing, are used to assess NHV.

Feedback is used to refine the cabin configuration, hardware design, and concept of operations.

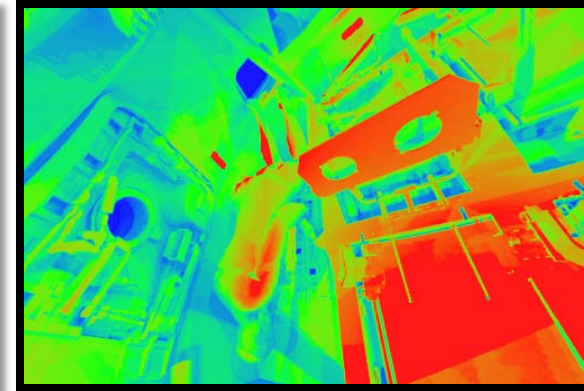
Orion Interior Lighting Analysis



CAD model-based lighting simulation allows the Orion lighting design engineers to interactively evaluate effects of changes in light fixtures, avoiding the need to create high-fidelity mockups.



Model View



Color-coded Illumination Plot

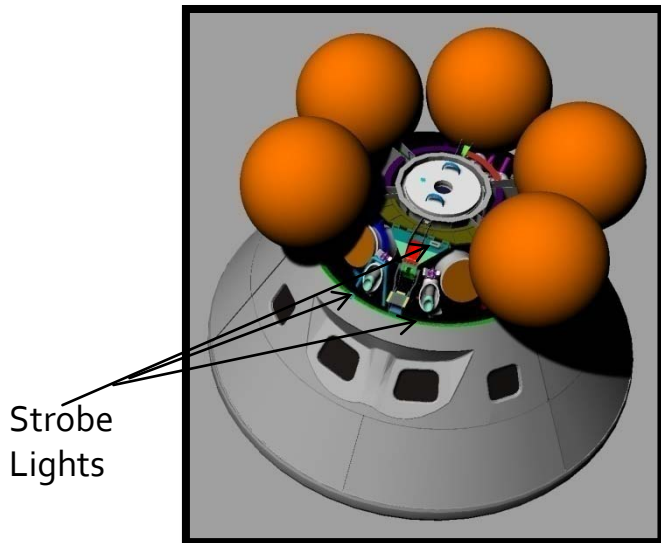
Lighting analysis shows that window refraction limits the panel area where sunlight strikes.

	Without Glass	With Glass
Model predicts front window sunlight on displays and control panel		
Model predicts side window sunlight on displays and control panel		

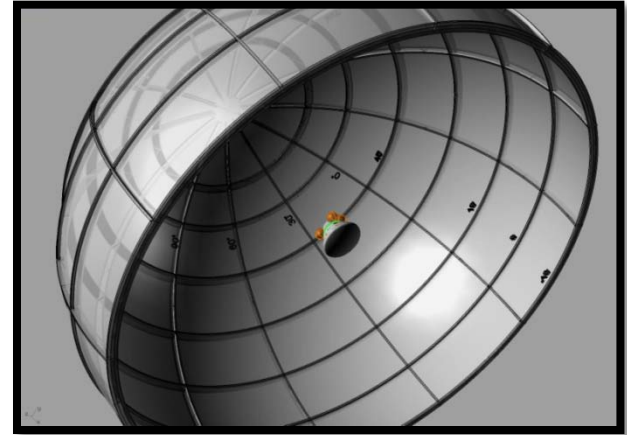
Orion Exterior Lighting Analysis



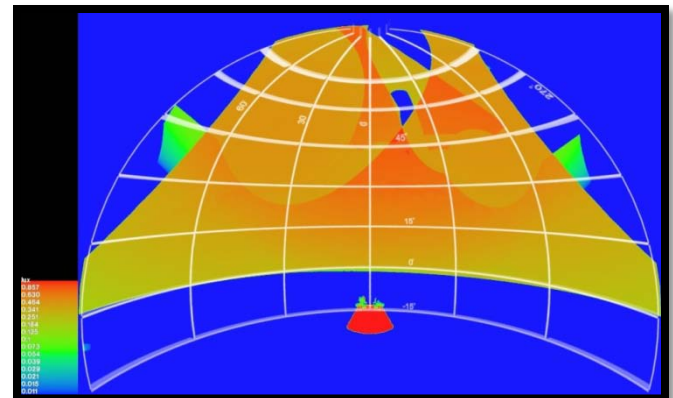
Analysis of exterior hardware interference with predicted recovery strobe light signals identifies design concerns early with minimal time and expense.



Strobe lights used upon landing as emergency beacons



Novel "projection dome" method illustrates the overall illumination pattern in one simulation/graphic.



Directed intensity values and shadow sources are easily identified.



Extravehicular Activity (EVA)

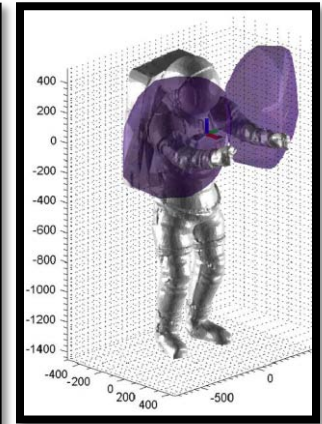
Motion Capture Technology



Evaluation of **Orion** pallet, seat, suit, display interfaces against known crew anthropometry

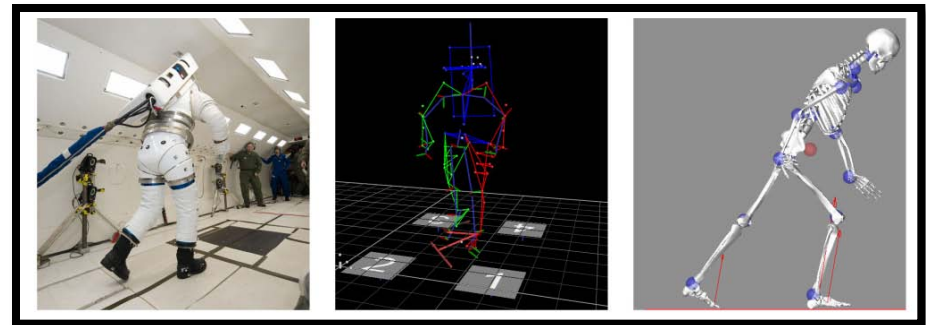


Improvement in the methodology for determining cycling of Cx EVA gloves by using motion capture



Benchmark current and future prototype suits through range of motion testing and task performance data (pressurized, unpressurized, 0-G, 1-G environments)

Creative adaptation and use of motion capture systems are used to develop suit requirements, evaluate suit design, quantify suit motion, assess suited human performance & accommodation.



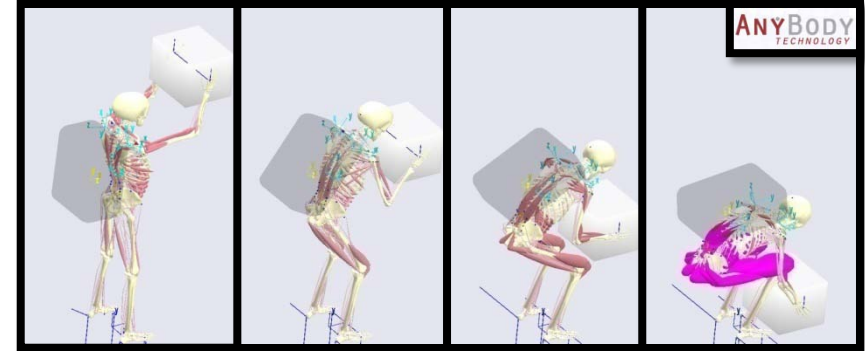
Motion data capture developed into a predictive computer model

Human Performance Modeling

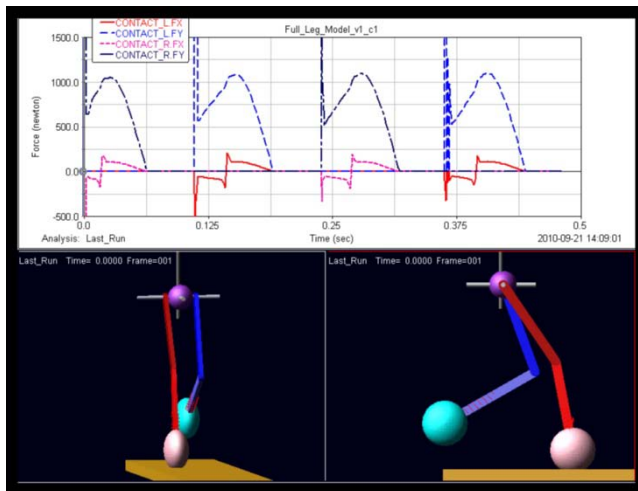


Anthropometry and biomechanics experts use dynamic modeling of human performance to provide:

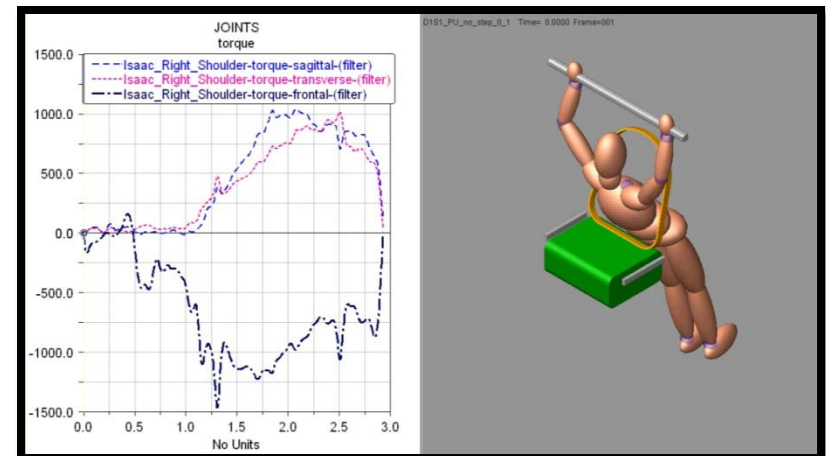
- Predictive human-machine interactions
- Predictive human-vehicle interferences
- Injury prevention analyses
- Recommended task strategies for optimal performance



Modeling the effects of the center of gravity position of Portable Life Support System (PLSS)



Human running model for the T2 treadmill & Vibration Isolation System on board the ISS.

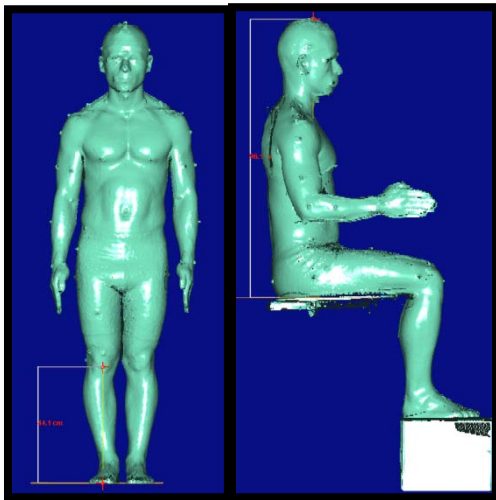


Dynamic musculoskeletal modeling in shoulder injury prevention during donning and doffing of suits

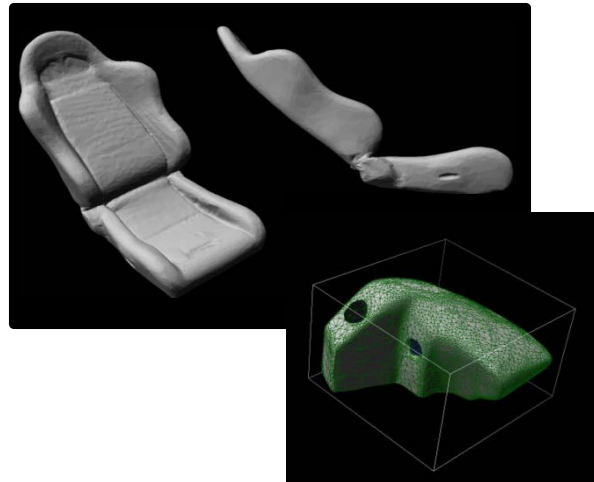


Whole Body Laser Scanning

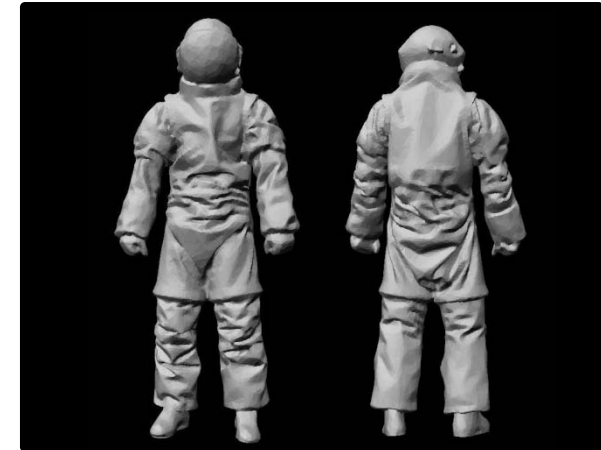
The collection and maintenance of a consolidated anthropometric database of the crew population provides data required for analysis of accommodation for Constellation suits, seats, vehicles, and other hardware.



Collection of anthropometry critical to crew accommodation in the suit and vehicle

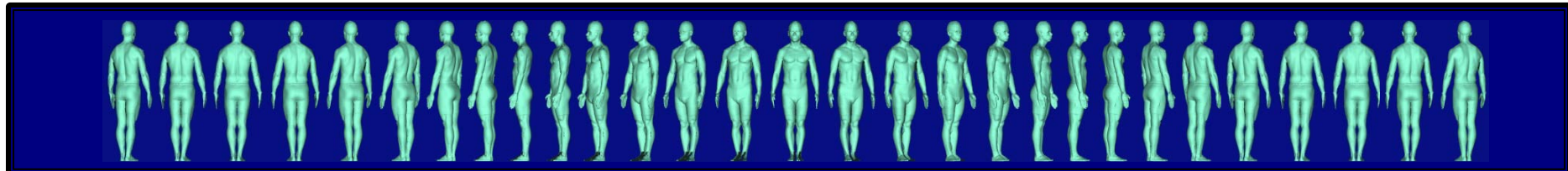


Scanning of prototype designs for fast 3D importation into models



Suit scanning for volumetric-based analysis and comparisons

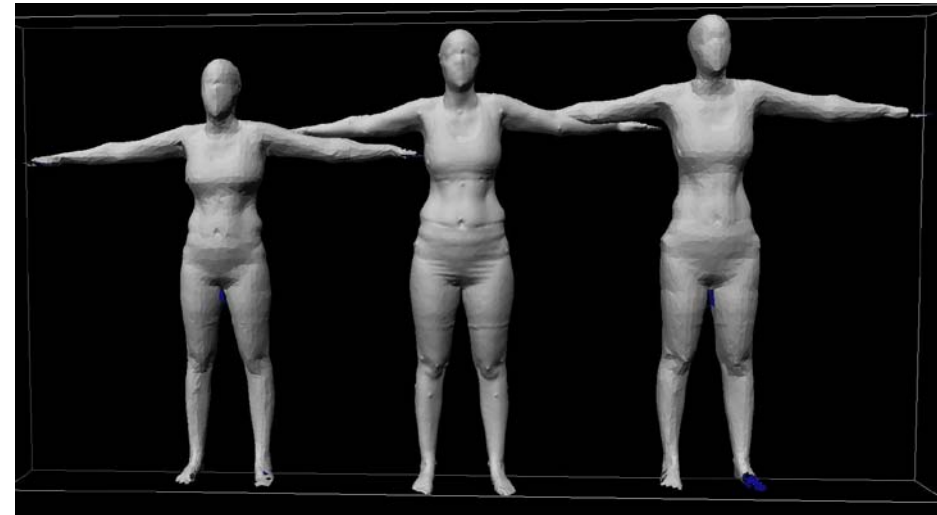
- Easy scanning of crew and/or hardware
- Captures a large amount of data
- Short data collection time (10-12 seconds per scan)
- Measurements can be easily verified
- Scanned images saved for future use



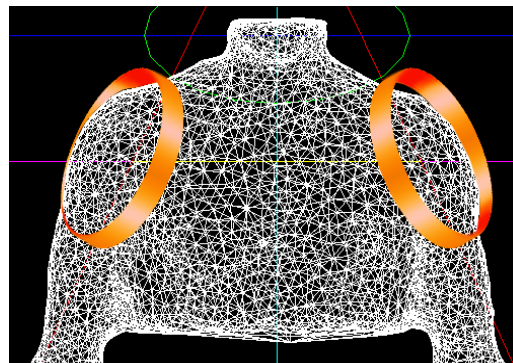
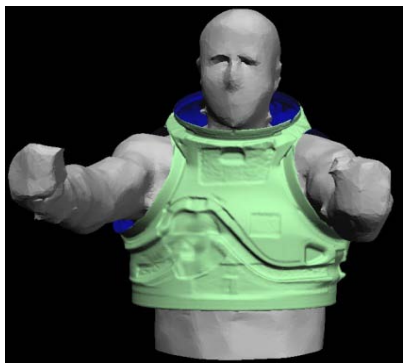
Volumetric Analysis



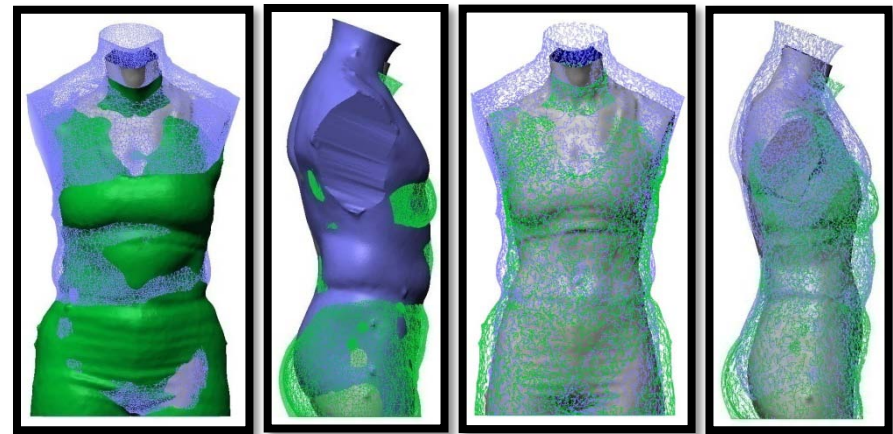
Volumetric Analysis using a consolidated crew anthropometry database assists in resolving issues of EVA suit fit, injury, and hardware design (e.g., number of sizes, adjustment points, interferences).



Morphing of baseline 3D scans generates realistic manikins matching a targeted selection of anthropometric measurements



Evaluation of EVA suit shoulder bearings in order to maximize performance and prevent shoulder injury



Evaluation of variability across individuals to drive EVA suit design

Volumetric overlay of suit components show interferences across known population and determine critical suit dimensions

EVA Communication, Avionics & Informatics

Evaluation of visual and auditory methods of information display aids system designers at Glenn Research Center in the selection of technology for the presentation of EVA procedures.



Human factors heuristic and usability evaluations optimize the electronic cuff and voice recognition systems (e.g., terminology to match the task).



Evaluation of simulated geology tasks using a Head-Mounted Display (HMD) and voice recognition system provides design recommendations for viewing EVA procedures.

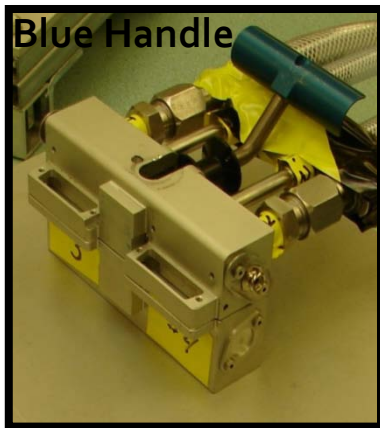
EVA Umbilical Connector Design



Usability evaluations, early and often, influence progression of the Constellation EVA umbilical connector design, location, and orientation on the suit.



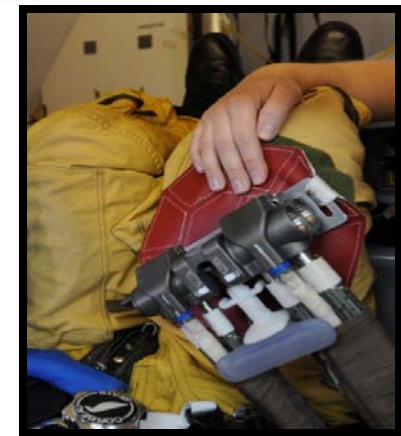
Chest location was eliminated due to occupant protection and Orion operability issues.



Initial connector design with small blue handle.



Human factors input and evaluation led to handle shape change.



Usability evaluations determined the optimal connector location, orientation, and design on the right thigh.

EVA Integrated Tests



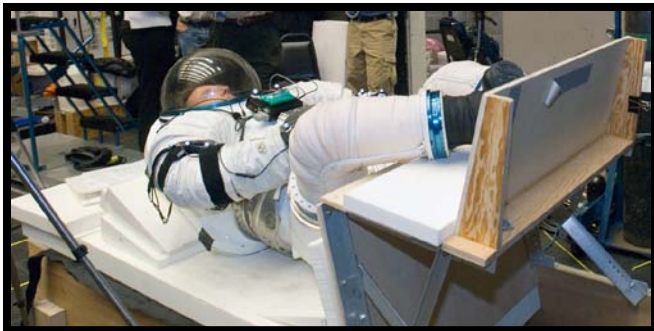
Human factors and EVA personnel evaluate suited operations to improve human performance, maneuverability, interferences, and efficiency for the next generation suits for Orion and Lunar Surface Systems.

1-g Evaluations

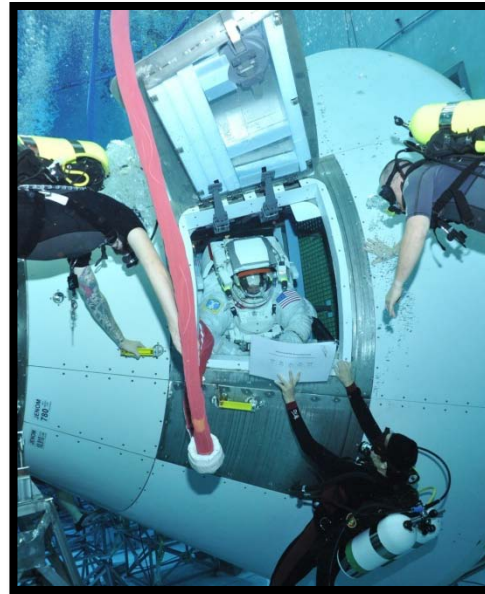
Reduced Gravity Evaluations



Orion Emergency pad egress



Launch seat comfort evaluation in planetary EVA suit



Evaluation of Orion EVA installed handrails and hatch operations, using HRP-developed Maneuverability Assessment Scale and anthropometry data.



Lunar 10km walkback test



Human performance assessment at different center of gravity locations



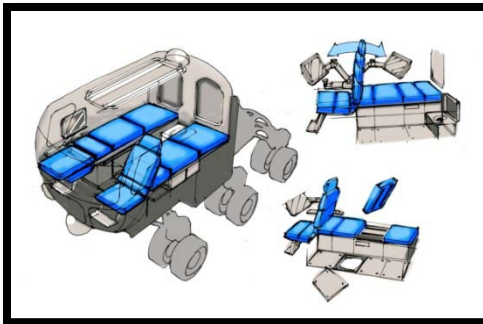
Lunar Surface Systems

Surface Exploration Vehicle (SEV)

Interior Configuration Design



From conceptual design through iterative evaluation, designers and human factors personnel work together on development of SEV interior configurations to enhance safety, performance, usability, and comfort.



Various images showing the development of the internal space of the SEV from concept to reality. Development begins with initial concept drawings of SEV interior (far left), followed by building of a mockup, and testing and redesign with human factors input.

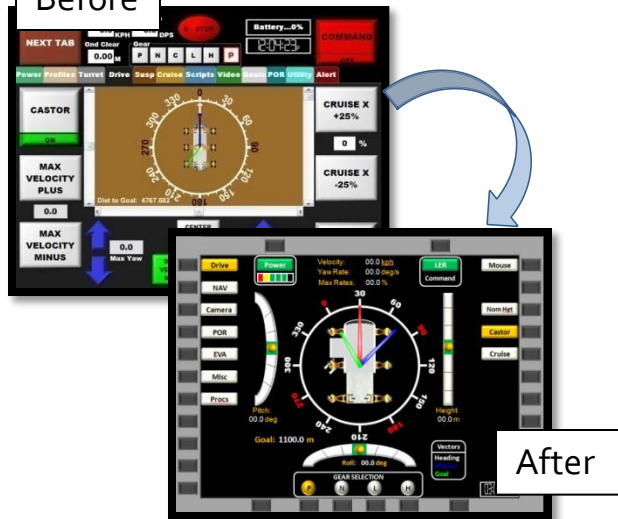
Surface Exploration Vehicle (SEV)

Display and Windows Design



Applying human factors principles and evaluation of critical tasks to display design and window placement improves usability and situational awareness.

Before

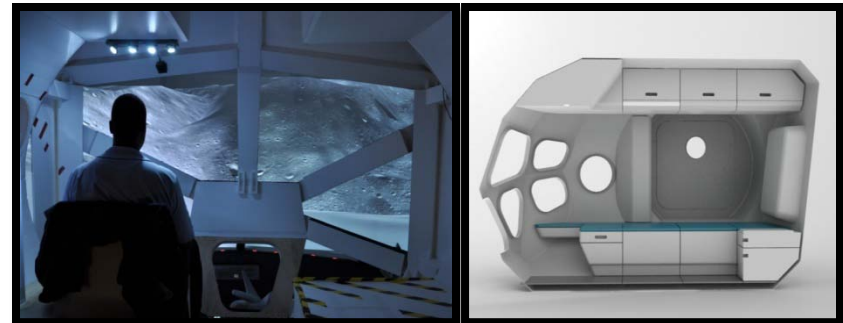


Display design before and after human factors input and evaluation.



Placement of displays.

After



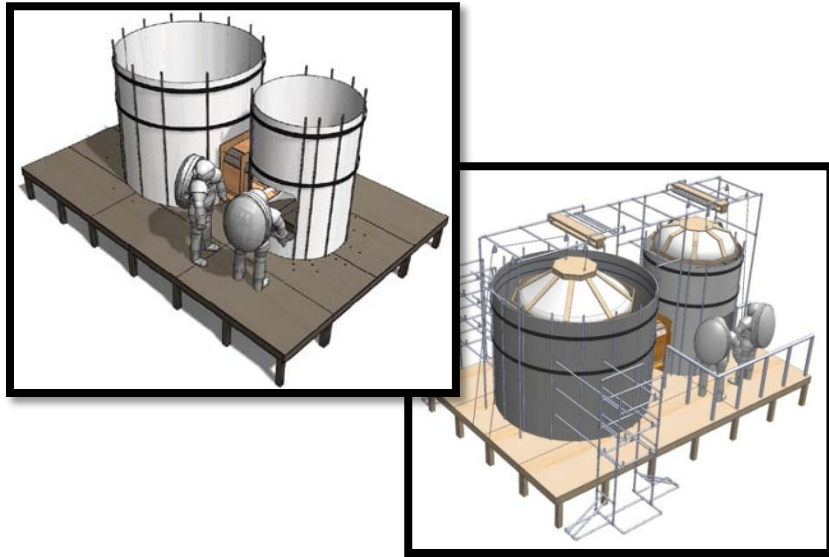
Testing of different window configurations in the Reconfigurable Orbital Cockpit (ROC) facility followed by a CAD design of the recommended design.

Altair Lunar Lander

Net Habitable Volume (NHV) Evaluations



Human factors evaluation of the Altair Net Habitable Volume improves mission safety and success for a crew of four during a seven day sortie mission.



An adjustable mockup was built representing the Ascent Module and Airlock. Diameter and ceiling height were designed to be modifiable to look at various habitable volumes.



Stowage configuration before and after human factors evaluation.



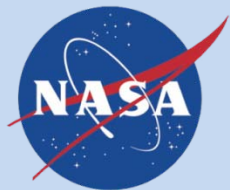
Evaluation of volume driving tasks, such as EVA preparation, were used to assess NHV.

Feedback has been used to refine the concept of operations.



International Space Station

Flight Crew Integration (FCI) International Space Station (ISS) Life Sciences Crew Comments Database



The Flight Crew Integration (FCI) ISS Life Sciences Crew Comments Database is the most complete archive of ISS crew debrief data in existence.



FCI ISS Life Sciences Crew Comments Database

This Site: FCI ISS Life Sciences

FCI ISS Life Sciences Crew Comments Database Site Action

View All Site Content

Documents

- Tools
- Review and Edit Page
- Source Documents
- Form Library
- Report Library
- FCI Data Connections
- Work Files
- Documentation

Lists

- Calendar
- Tasks

Pictures

- Photo Gallery

Discussions

- Team Discussion

Sites

- People and Groups

Recycle Bin

A SharePoint site used by the ISS Flight Crew Integration (FCI) team to manage and trend ISS Expedition crew data in support of exploration activities.

Lessons Learned Documents

Type	Title	File Size
Document	E19/20 Lessons Learned	102 KB
Document	E18/19 Lessons Learned	111 KB
Document	E18 Lessons Learned	109 KB
Document	E16/17 & E17/18 Lessons Learned	245 KB
Document	E16 Lessons Learned	132 KB
Document	E15 Lessons Learned	135 KB
Document	E14 & E14/15 Lessons Learned	207 KB
Document	E13/14 Lessons Learned	119 KB
Document	E13 Lessons Learned	123 KB
Document	E12 Lessons Learned	131 KB

1 - 10

Announcements

Expedition 22/23 Debrief data was added to the database on 8/20/10
by Schuh, Susan V. (JSC-SP) [WYLE INTEG. SCI. & ENG.] 9/3/2010 9:22 AM

E23/24 Debriefs
by Bagian, Krista Rose. (JSC-SP) [WYLE LABS] 9/3/2010 9:21 AM
The E23/24 US crewmember will return in late September (9/23) onboard 225. Debriefs will begin in mid-October.

Calendar

10/18/2010 8:00 AM **E23/24 Debriefs with Tracy Caldwell (tentative)**
• Oct 18th weeks 2 options: Option 1 – TC travels to Moscow for Russian debriefs/Welcome Ceremony;
Option 2 – TC starts US Technical debriefs

Presentations

Type	Title
Document	Roadshow_Presentation_FCI Db
Document	OpHab PRM
Document	FCI Roadshow Presentation 2010 PPT
Document	FCI Roadshow Presentation PDF

Approved Data Summaries

- Habitable Volume
- Waste and Hygiene
- Labeling
- Robotics
- Procedures
- Planning
- Human Computer Interaction

(More Links...)

Secure SQL repository that allows for the systematic search of over 35,000 crew comments from ISS post flight crew debriefs for Expedition 1 to the present.

Valuable resource which allows for the creation of products and use of data to support design & development of vehicles, hardware, requirements, procedures, processes, and research protocols for current & future spaceflight programs.

FCI ISS Life Sciences Crew Comments Database SharePoint Site

International Space Station

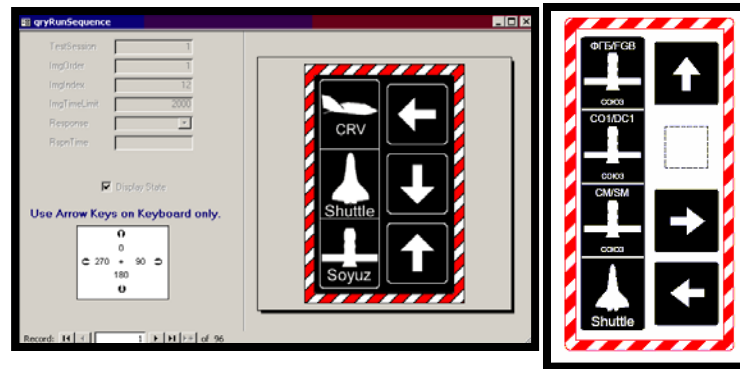
Human Factors Research



Human factors evaluations improve the implementation of hardware, placard, and procedure designs for ISS emergency operations.



Guidelines based on eye tracking studies contributed to the ISS medical pack redesign.

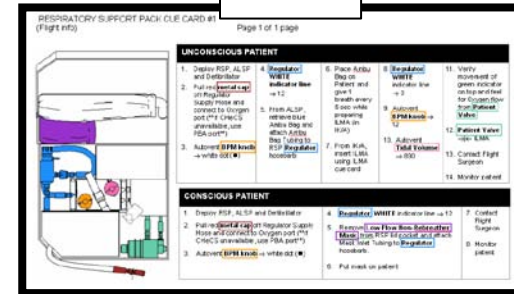


A multi-egress placard evaluation led to modified placards placed near ISS hatch entrances, indicating the direction to the emergency escape vehicle.

Before



After



Through iterative design and evaluation, a time savings of **3 minutes** was achieved for the redesigned Respiratory Support Pack (RSP) cue card procedure.

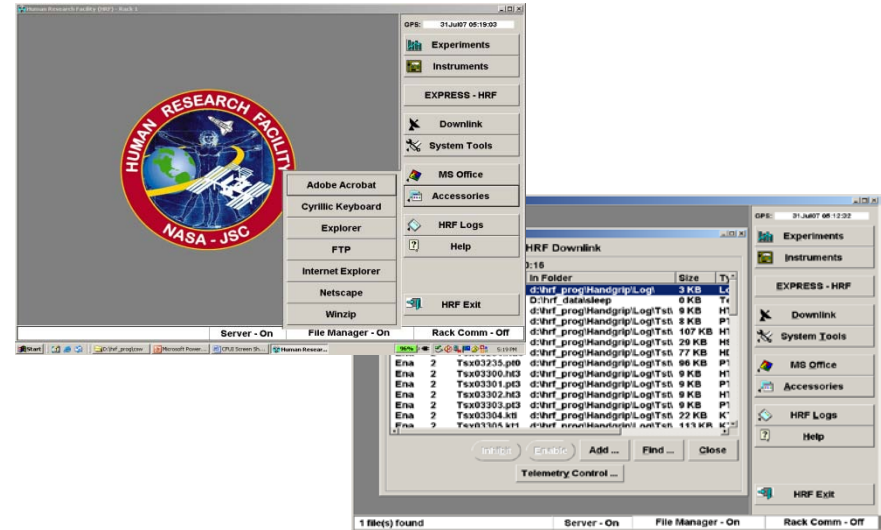
International Space Station Payload Display Design



Human Factors engineers support the design of usable spacecraft displays through development of requirements and an iterative design-test-redesign process.

The displays receive positive feedback during crew debriefs on ease of use, consistent software platform, and good science return.

Requirements and lessons learned from ISS are leveraged for Orion design and evaluation.



ISS Payload Common Software displays developed as a result of iterative design and crew testing



Crewmember participating in ISS Payloads display evaluation



Human Research Program

Human Research Program Directed Research

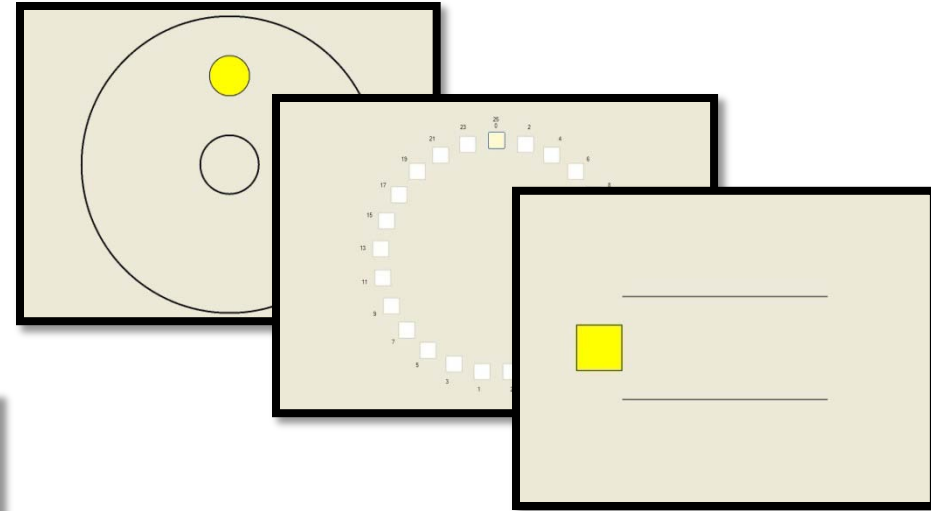
Cursor Control Devices (CCD)



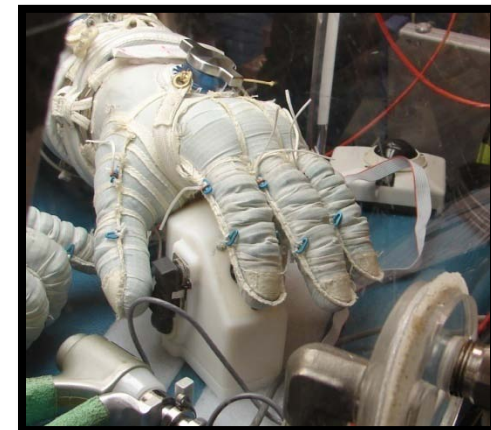
Human Factors research has aided the Constellation Program in the development requirements for the design of gloves and controls that must be operable in extreme environments such as high g, vibration, microgravity, and pressurization.



Selection of desired control characteristics



CCD Test Battery



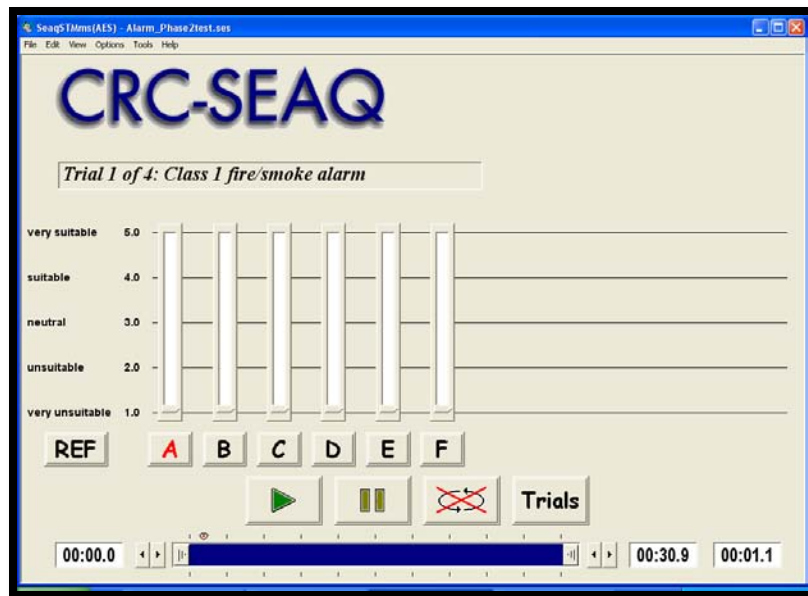
Pressurized functionality testing

Human Research Program Directed Research

Auditory and Visual Displays



Empirical results from Human Factors research drive requirements generation and evolution, yielding improved safety and productivity.



Evaluations of different auditory alarms result in design requirements and standards for future space vehicles.

elapsed time 34
upper limit 21
analog input close
total pressure left

With long labels, word values take longer to process than numeric values.

Cooling unit 69
Nominal force 79
Vent 11
Fan 34

Search times are faster when using a combination of short and long labels.

Horizontal
90 Left
90 Right
Marquee

Horizontal text preferred. If vertical text must be used, avoid marquee style

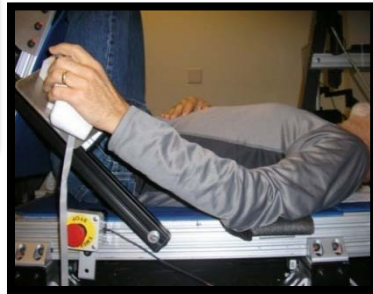
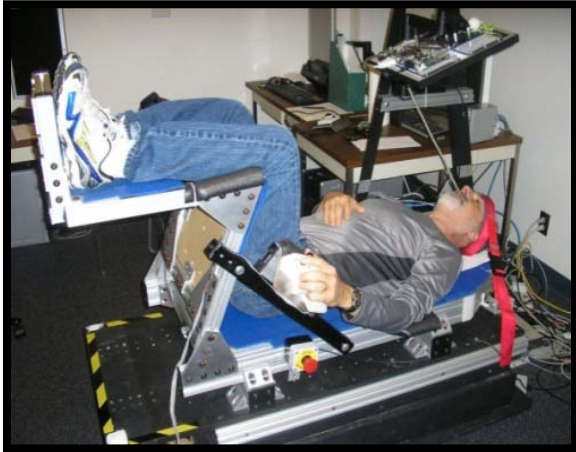
Evaluations involving visual search times and errors for labels and values as a function of different types of alignment, orientation, and formats provide information for design and standards development.

Human Research Program Directed Research

Performance under Vibration



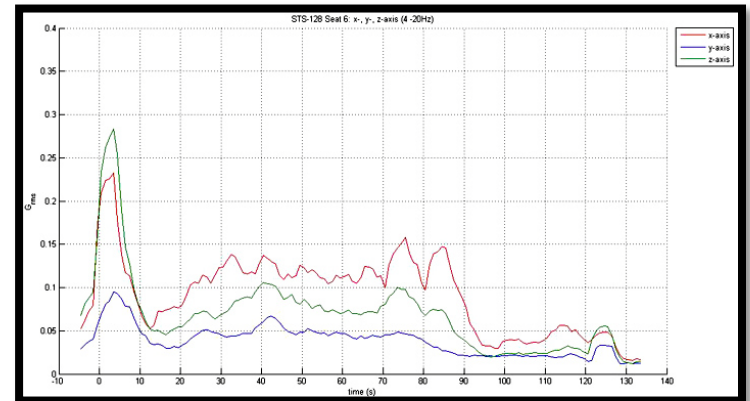
Evaluations of readability and cursor control operations under vibration lead to the development of vibration requirements for optimal crew performance.



Cursor control device being tested in vibration chair.



The placards used during flight are shown at post-MECO for STS-119 (left) and pre-flight for STS-128 (right).



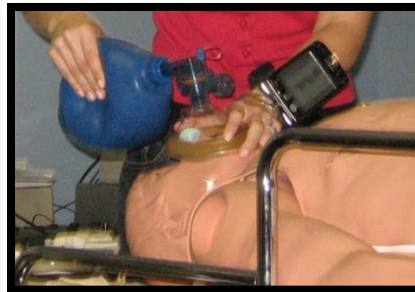
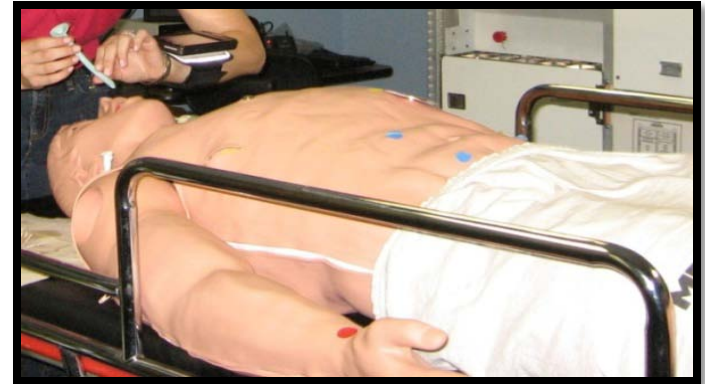
Vibration profile from STS-128.

Human Research Program Directed Research

Medical Just-in-Time Training



Display technology evaluations for simulated just-in-time procedures using a human patient simulator provide new insights into use of electronic procedures during medical operations.



Head Mounted Display (HMD) and wrist-mounted PDA were evaluated with a paper cue card.

Wrist-mounting the PDA is a viable hands-free option for just-in-time procedures.

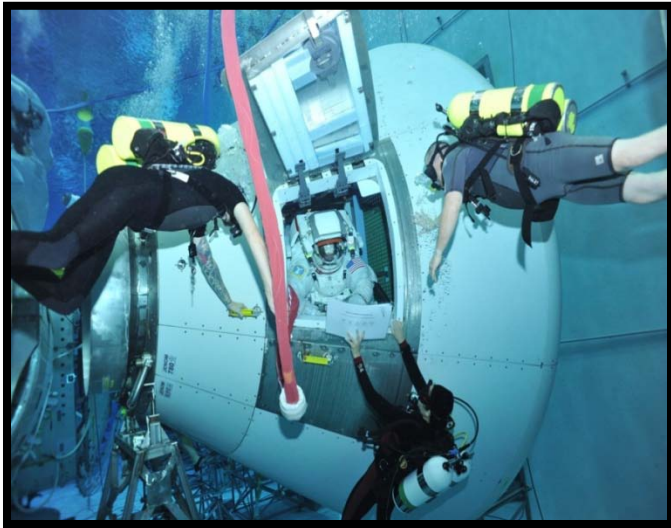
Alternative methods for scrolling on the smaller display screens are needed to facilitate hands-free commanding.

Human Research Program Directed Research

Maneuverability Assessment Scale

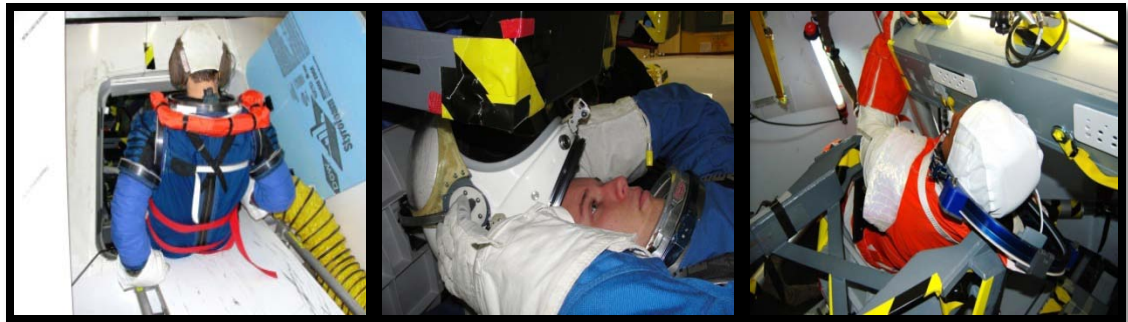


The Maneuverability Assessment Scale (MAS) allows for real-time data collection of suited maneuverability, by providing a subjective assessment of a well-defined mobility concept.



The MAS was administered real time during a Neutral Buoyancy Lab (NBL) evaluation where the crew assessed their maneuverability while translating the exterior as well as ingressing and egressing the Orion mockup hatch.

Maneuverability Assessment Scale				
My ability to move in any direction at my desired pace and accuracy is:				
<u>Excellent</u> Not affected	<u>Good</u> Slightly affected	<u>Fair</u> Moderately affected	<u>Poor</u> Significantly affected	<u>Very Poor</u> Severely affected
1	2	3	4	5



The MAS was administered during a space suit initial characteristics evaluation. Ratings were given for ingressing and egressing both vehicle and seats as well as donning/doffing helmets while seated.

Human Research Program Directed Research Usability



HRP research yields NASA's first ever requirement for usability. By requiring usability testing and compliance with error rate limits, this requirement helps ensure a well-designed, human-rated spacecraft.

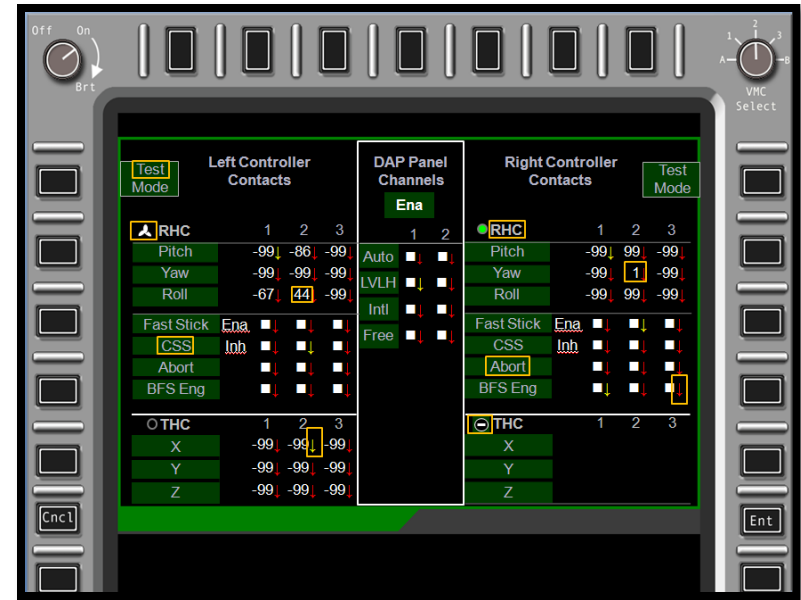
Revised consistency scale

1. Text – Headings, labels, body text, acronyms, abbreviations
Text of similar function/level should be visually and semantically consistent within the system.

○ Applicable ○ Not Applicable

#	Consistency attributes	Rating (1 = very inconsistent to 3 = very consistent)				Comments
Visual attributes						
1.1	Color	1	2	3	N/A	
1.2	Location	1	2	3	N/A	
1.3	Alignment	1	2	3	N/A	
1.4	Font	1	2	3	N/A	
1.5	Size	1	2	3	N/A	
Semantic attributes						
1.6	Meaning	1	2	3	N/A	
1.7	Terminology	1	2	3	N/A	

A System Consistency Scale was generated for use in hardware and software design assessments



A legibility methodology was created and validated for spacecraft verification.

A review of usability metrics related to efficiency, effectiveness, and satisfaction yielded standards for NASA-STD-3001.

Mobile Information System Technology (MIST)



The MIST is a flexible, mobile, electronic information system for hands-free operations. The system provides reduced task time and mass over the traditional computer workstation and improves crew productivity and performance.



The system is composed of several components: a head-mounted display (HMD), camera near the eyes, voice input and communications, and audio outputs all connected to a mini-computer and wireless transmitter/receiver.



The HMD of the MIST provides procedural information and video playback features, allows crewmembers to overlay an augmented reality in their visual field to aid in information display, and exchanges both auditory and visual data inputs allowing for quicker access to data.



Habitability & Human Factors Branch (SF3) Facilities

Anthropometry and Biomechanics Facility (ABF) Overview



The **Anthropometry and Biomechanics Facility (ABF)** is uniquely equipped to conduct a variety of space biomechanics and ergonomics research studies that deal with issues humans will encounter while living, working, and exploring in space. The ABF provides anthropometry and biomechanical analysis and evaluation expertise to the Habitability and Human Factors Office, Extravehicular Activity Projects Office, Constellation Office, and other internal and external organizations.

Key Functions:

- Full crew population accommodation in vehicle/suit
- Requirements definition and compliance – anthropometry, strength, range of motion, mobility
- Ergonomics and biomechanics evaluations
- Suited locomotion evaluations
- Astronaut Candidate Testing (anthropometry and strength)
- Whole-Body Functional Anthropometry – Suit sizing, volumetric analysis, evaluation of suit sizes
- Crew induced loads for in-space activities – tile repair techniques, center of mass, and weight assessments



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Anthropometry and Biomechanics Facility (ABF)

Facility and Tools



- The ABF has state-of-the-art human strength and performance measurement devices. Some of these instruments include:
 - Whole-Body Laser Scanner
 - Foot and Hand Scanner
 - Three-dimensional video and non-video based motion tracking systems (Measurand ShapeWrap™, Vicon™ and Visualeyex™)
 - Six-degree of freedom force plates
 - Load cells
 - Dynamometers
 - Pressure transducers
 - Anthropometers
 - FARO Arm
 - Biodex, Primus, Jamar Hand Grip
 - Noraxon Electromyography
- Software Tools:
 - AnthroScan, ScanWorx, Polyworks, RapidForm
 - Vicon, DartFish
 - RAMSIS, LifeModeler
 - SPSS Statistics Software
- When needed, the following NASA facilities are utilized for reduced gravity research and testing in addition to the ABF:
 - Sony Carter Training Facility Neutral Buoyancy Lab (NBL)
 - Extra Vehicular Mobility Unit (EMU) Laboratory
 - Microgravity Aircraft
 - BLD g Precision Air Bearing Floor (PABF)
 - BLD g Partial Gravity Simulator (POGO)
 - BLD g Active Response Gravity Offload System (ARGOS)



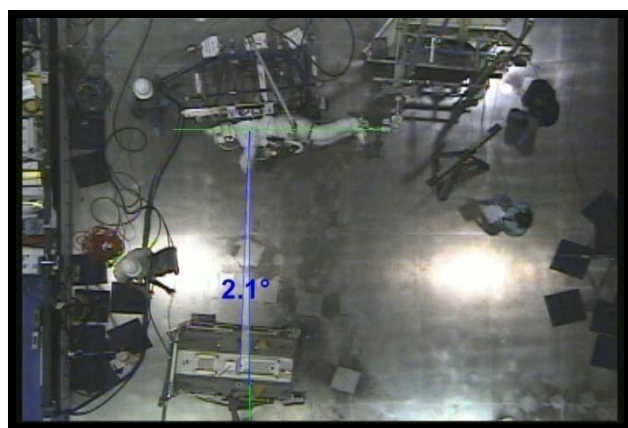
Anthropometry and Biomechanics Facility (ABF)

Instrumentation



Custom built, adjustable mockup allows for motion capture data collection

Experts design custom instrumentation and models to support a wide-range of activities such as hardware design, requirements development, and astronaut training.



Determined velocity and target vector for astronaut operations to safely launch the Early Ammonia Servicer (EAS) from station.

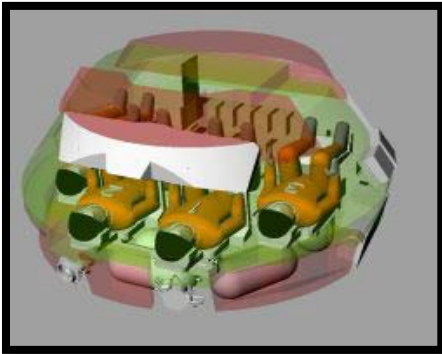


Calculated the depth of damage and amount of vibration on robotic arm during tile repair



Developed model to improve weigh outs of divers for training at NBL

Graphics Research Analysis Facility Overview

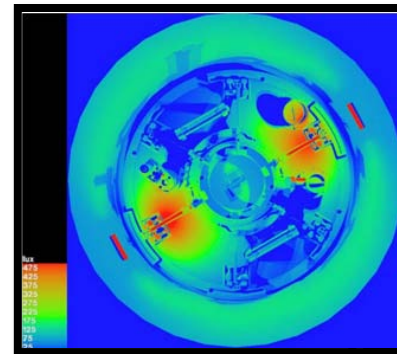


Net Habitable Volume Study

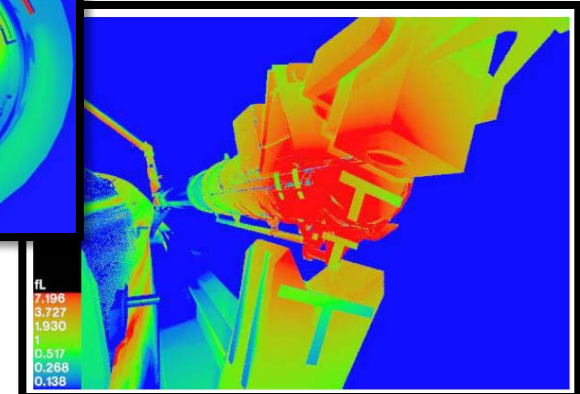
The **Graphics Research Analysis Facility (GRAF)** performs computer-aided human factors analyses to address human engineering issues for space design and analyses. Capabilities include human modeling, habitability, computer animation, lighting and viewing analyses, operations analyses for activities internal /external to spacecraft, design concept visualizations, as well as research and development activities.

Highlights:

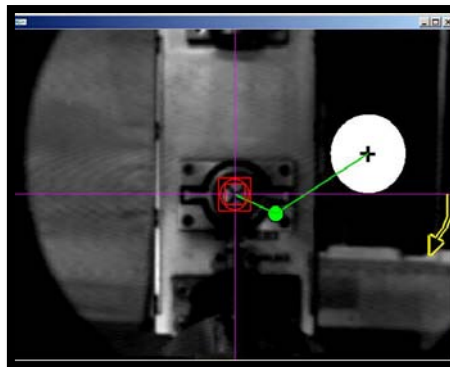
- Interior Illumination Maps of Node 2, JEM-PM, JEM-ELMPS, Columbus
- Personnel have 20 years of experience working Shuttle, Mir, ISS, Constellation Program analyses
- Validated data and configuration control ensure quality results



Hatch lighting



Shuttle Camera lighting



Target Overlay Study

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Graphics Research Analysis Facility

Hardware and Software Tools

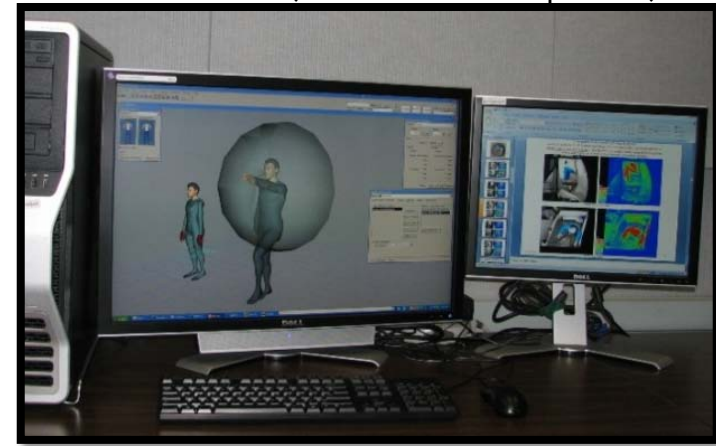


Hardware Tools:

- High performance CAD workstations running 64-Bit processors capable of manipulating extremely large 3D models
- Windows and Linux software development workstations
- Beowulf Computing Cluster running CentOS 5 Linux for producing up to 96 lighting images in parallel
- Viewing on large, high resolution monitors (30 inch, 2560 by 1600 pixels)
- Multiple terabyte Linux servers
- High speed gigabit LAN connecting workstations

Software Tools:

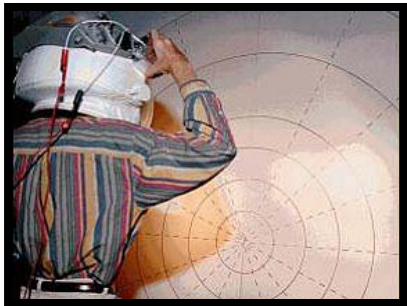
- CAD/Modeling Tools
 - Pro/Engineer (Pro-E)
 - 3D Studio Max (3D modeling, animation, and rendering)
 - Deep Exploration (CAD model conversion)
 - Quicktime Pro (animation generation)
 - Radiance (lighting visualization)
 - JACK (Human Modeling)
 - Midas and Imprint (3-D rapid prototyping, human performance modeling and simulation)
 - Rhino 3D (modeling and translation)
- Other
 - Polyworks 3D Metrology Software Platform (point cloud engineering)
 - Visual Studio (software development)



Lighting Environment Test Facility Overview

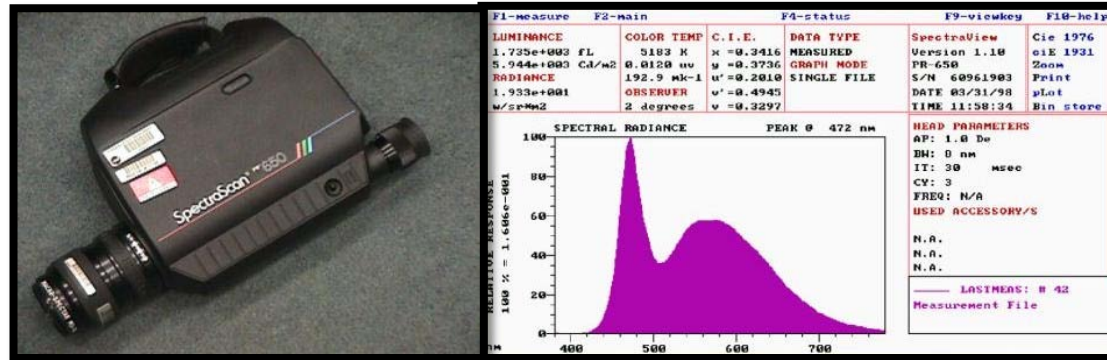


The **Lighting Environment Test Facility (LETF)** investigates and evaluates proposed lighting systems for use on space vehicles to enhance the crews' direct and indirect viewing. This effort includes the investigation, measurement and analysis of artificial lighting systems such as docking lights, portable lights and navigation lights; reflective characteristics of various materials, the effects of solar lighting; transmission characteristics of transparent materials used for visors, displays and windows; along with camera performance over the operational illumination range.



Facility and Tools:

- LETF Laboratory Facility – 18' x 45' controlled lighting space for data collection
- Illuminance and luminance meters
- Colorimeters
- Specroreflecometers
- Special purpose luminaires
- Computer modeling capability



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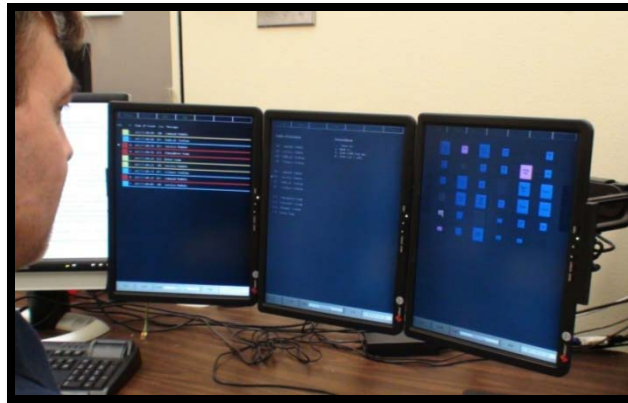
Usability Testing and Analysis Facility Overview



The **Usability Testing and Analysis Facility (UTAF)** provides analysis, evaluation and usability testing of crew interfaces for work areas and equipment. This includes computer displays and controls, workstation systems, and other types of crew interfaces. The UTAf has a unique capability with a staff experienced in the rigors of both cognitive human factors and ergonomic research and evaluations.

Key Functions

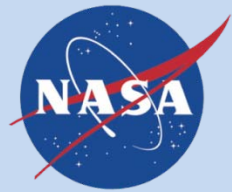
- Human factors consultant/team member
- Advocate for crew
- Facilitate Human-Centered Design
- Evaluate user interface designs through heuristic and established usability evaluation methods
- Space human factors research



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Usability Testing and Analysis Facility

Methods, Tools, and Processes



Methods and Processes:

- Human-Centered Design
- Human-system integration requirements development and interpretation
- Observational/Ethnographic studies
- Task analysis and function allocation
- Scenario and script development
- Information architecture and interaction design
- Human factors assessment
- Heuristic evaluation
- Cognitive walkthrough
- User testing/Human-in-the-loop testing
- User interface design and usability testing (e.g., websites, software displays, hardware panels and controls, and procedures)
- Applied human factors research
- Human performance modeling
- Error analysis
- Link analysis
- Workload and situational awareness
- Questionnaire and survey design



Facility and Equipment:

- Isolated subject and control rooms
- Video recording, editing, and analysis equipment
- Eye- and head-trackers
- Hardware and software tools
 - Flight-like computers
 - User interface prototyping tools
 - Specialized statistical analysis software
 - Survey software
 - User testing and recording tools with remote site testing capability
 - Multi-media, web-based, and statistical tools

Habitability Design Center

Overview



The **Habitability Design Center (HDC)** is a conceptual, human-centered design studio engaged in solving the unique challenges of living and working in extreme environments, providing advanced concepts to the NASA community using Human Factors as a design tool to develop products, systems, and architecture. By focusing on the needs of humans, the HDC creates and aids in product development that enhances crew productivity and well-being.

HDC's Mission:

- Provide innovative, integrated design solutions for streamlined cost effective manufacturing
- Provide unequalled design alternatives to the NASA community
- Dedication to end user satisfaction through innovative, leading edge solutions
- Cost effective, simple solutions
- Quality that lasts

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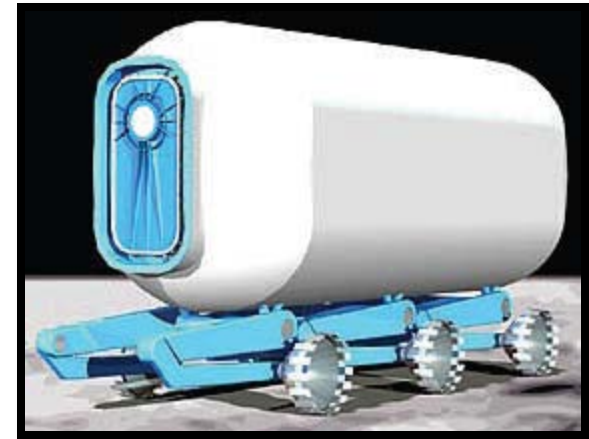
Rich Szabo 281-483-0363

Habitability Design Center

Capabilities



- Architects with direct experience in human-centered design for spaceflight
- Apply human-centered design principles and provide innovative, simple and cost effective solutions to design challenges
- Early prototyping and testing help save rework dollars
 - Designs enhance human micro gravity functionality, to save crew time and program money
 - In-house shop that can rapidly develop low cost mockups for hands-on evaluation
- Delivery of “close to production” CAD for fabrication, saving time and money
 - Leveraging the diverse expertise of the GRAF and IVC CAD groups



Space Food Systems Laboratory

Overview



The **Space Food Systems Laboratory (SFSL)** is a multipurpose laboratory responsible for space food and package research and development. This facility designs, develops, evaluates and produces flight food, menus, packaging, and food-related ancillary hardware for Shuttle, Space Station, and Advanced Food Systems.

Space Food Systems Mission / Purpose

- Provide high-quality flight food systems that are convenient, compatible with each crew member's physiological and psychological requirements, meet spacecraft stowage and galley interface requirements, are appetizing, safe, and are easy to prepare and eat in the weightlessness of space.



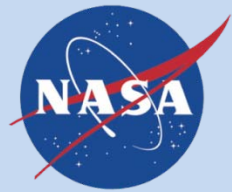
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Space Food Systems Laboratory

Facilities and Capabilities



■ Facilities and Equipment:

- Test Kitchen
 - fully equipped with sensory testing capabilities
- Food Processing Laboratory
- Food Packaging Laboratory
- Analytical Laboratory



■ Capabilities:

- Fabricate custom-molded flight food containers
- Process foods using a variety of stabilization techniques
 - including freezing and freeze-drying
- Package foods in a nitrogen environment for long-term storage
- Provide long-term controlled environment storage for processed foods
- Conduct physical and sensory analyses of food
- Evaluate prototype and flight food preparation hardware
- Develop food preparation
- Develop serving techniques for space flight

